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Smart Dual Dustbin Model for Waste Management in Smart Cities

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Abstract—As urbanization is spreading rapidly, there is an increase in production of waste. Waste management is a crucial issue to be considered at public places where waste is overflowed from the bins and may cause different diseases. The present work focuses to develop a model of smart dustbin which can be effectively used at public places in smart cities. The model has two dustbins (named as Dustbin A and Dustbin B) which will be kept at public places mostly. Dustbin A can be used but Dustbin B cannot be used until Dustbin A is full. Dustbin B can only be used once Dustbin A is full and then Dustbin A will not open until the waste is cleared in the Dustbin A. Whenever any dustbin is filled up, a message is sent to the concerned authority. This will avoid overflow of waste in the bin. Dustbins have automatically close and open feature depending on the presence of an obstacle. In our system, the garbage level in the dustbins is detected with the help of Ultrasonic sensor and presence of the obstacle is detected by IR Sensors and communication to the authorized control room by GSM system.

Keywords: Smart Dustbins, Arduino, Ultrasonic sensor, GSM, Waste management, IR sensor

I. INTRODUCTION

Garbage has been a big problem in most of the cities, where very often one can see the pictures of garbage overflow. Amount of garbage waste is generally determined on the basis of two major factors, the population in a given area and also on consumption patterns. They are lakhs of bins at public places but still, there is waste overflow from these bins as they are not automated. The user of the bin throws the waste and do not care for the overflow. If waste overflow from dustbins is solved, it decreases foul smell in surroundings of bin and users will use the bin with comfort. Therefore, waste collection and management is becoming a huge challenge for Municipal Corporation of a city. In general, the garbage wastes are collected manually after visiting the entire area by the corporation vans, which is a tedious and sometimes faced huge challenge to manage the entire city. Moreover, in big cities, where extensive numbers of dustbins are deployed, physically hunting down and cleaning in routine basis is challenging. The garbage bins may get filled early or may get damaged, which requires immediate attention to resolve the problems or the bins should itself has the smart facility to address the problems. Therefore, smart and efficient management of the waste is one of the focused areas in all the projects on the smart city, smart living.

In literature, several research groups have attempted to mitigate this waste management issues, but a few works have been aimed to address both the bin monitoring and waste collection efficiently. In [1], S. Vinoth Kumas et al. used sensor system to check the waste level over the dustbins and send the information to concerned authority through GSM/GPRS. However, the model lack of automating access to individual bins and locking a particular bin when it is filled.

Further, Shubham Thakker and R. Narayanamoorthi [2] utilized Near Infrared Reflectance (NIR) spectroscopy to identify any kind of plastic waste and GSM technology for communication. Similarly, in [3-5] authors used Radio Frequency Identification (RFID), Geographic Information Systems (GIS), Positioning System (GPS), transportation model, cloud computing [5] for bin monitoring and waste collection. These simple RFID or GPS based monitoring systems are not smart solution to implement on a citywide scenario as installing individual GPS chip in all the dustbins along with access the dustbins always with RFID card is costly and tedious jobs. Recently, A. S. Bharadwaj et. al [6] presented a conceptual approach for solid waste management to mitigate these challenges. Their model consists of GPS and internet enabled Smart Dustbin with Intel Galileo as a central control unit. But still, the system is not fully automated to access the dustbin.

Therefore, it is quite evident that most of the existing models so far just sends the message once the dustbins get filled, but there is no solution if authority will not have enough time to pick the waste effectively or in between if the dustbins get damaged/leaks. Further, there is no proper solution to automatically open and close the lid of the dustbins. Most of the cases users manually open the lid to through the garbage, which may cause several infected diseases. Keeping in mind all these issues the present work proposed a fully automated waste management systems, which consists of two dustbins which will

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be kept at public places mostly.The bins are equipped with IR sensors to automatically open and close of the lid, an ultrasonic sensor to measure the level of dustbin being filled up and GSM Modem to alert authority once the bin is full. This will avoid overflow of waste in the bin. The detailed model and corresponding results are discussed in the subsequent sections.

II. Proposed Design And Working Principle

The proposed system consists of double dustbins, where second Dustbin B cannot be used until and unless Dustbin A is fully filled. Dustbin B can only be used once Dustbin A is full and then Dustbin A will not open until the waste is cleared in the bin A. Two IR sensors are placed in the front of the bins so that whenever any person comes in front of dustbin it opens and closes automatically using a servo motor. Further, ultrasonic sensor is placed inside the bins to detect the level of dustbin being filled up. Once the Dustbin A or B gets filled up a message is sent to the concerned authority via GSM module. Figure 1 shows the block diagram of the proposed design. The Arduino Uno (Atmega 328) is a main controller unit to which all other sensors are connected. The proposed system will work with12V battery supply. The Ultrasonic sensor, GSM modem and Arduino are interfaced in such a way that message is sent when waste level reaches a threshold level. Similarly, Servo motor, Arduino and IR sensor are interfaced in such a way that when an IR sensor senses an obstacle, the lid of the dustbin opens automatically. The detailed descriptions of the individual components are given below.

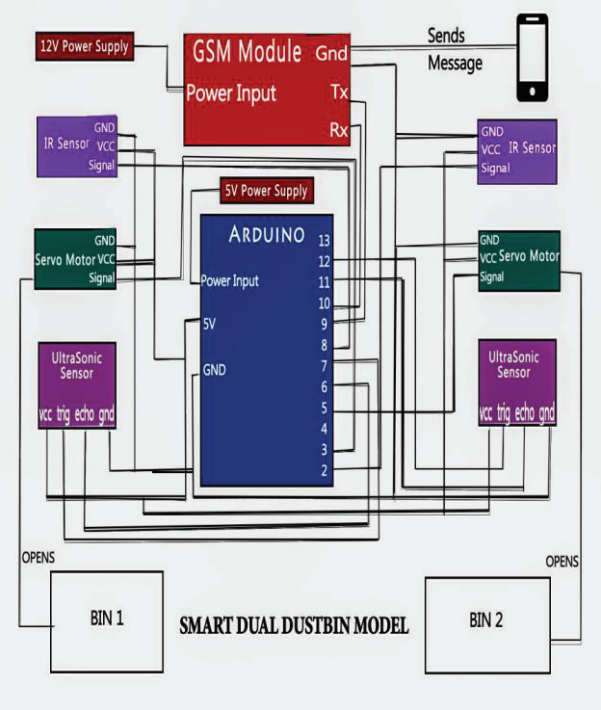

Fig.1: Block diagram of our Dual Dustbin model

GSM Sim 900A Modem: In the present model GSM module plays an important role by sending messages to the control room if the bins are full. The modem works in frequencies of 900/1800 MHZ. The RX pin of the modem is connected to pin 10 of Arduino and the TX pin is connected to the pin 9 of Arduino. The modem has an SMA connector with GSM Antenna and a sim card holder. The modem is given an external power supply of 12V.

Servo motor: Servo motor is used to open the lid of the dustbin if there is an obstacle in front of the dustbin. In our model, it's functionality depends on the values of IR Obstacle sensor and the servo is turned 180 degrees to open the lid. Generally, the angle can be adjusted between 0-180 degrees. The servo library is used in Arduino IDE to control the motor. The Servo motor contains Ground, V_{CC} and output pin.

Arduino Uno: We have used Arduino Uno as a microcontroller board with ATmega328p microcontroller. Arduino has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. 6 pins out of 14 digital pins can be used as pulse width modulation (PWM) pins.

IR Obstacle Sensor: The IR sensor is used to detect the presence of an obstacle in front of the dustbin. It has an IR emitter and a receiver. Generally, this sensor has a high precision. The IR obstacle sensor has a potentiometer which can be used to adjust the range of measurement. The onboard LED indicator is used to check the presence of an obstacle.

Ultrasonic Sensor(HC-SR04): In our model, Ultrasonic sensor is used for monitoring the level of waste in bins. An Ultrasonic sensor can measure in the range of 2cm – 400cm. The sensor includes a transmitter, receiver and control circuit. The sensor transmits a sound wave of frequency 40 kHz and detects whether there is a reflected pulse signal back. The sensor has an echo pin, trigger pin, VCC, and ground.

Distance = (high level time × velocity of sound (340 m/s)) / 2.

The model consists of GSM/GPRS Modem with standard communication interfaces like RS-232 (serial port), USB, so that it is easily connected to other devices. The ultrasonic sensor is used to find the height of garbage filled at different intervals of time. The dustbin automatically opens and closes if any person comes in front of him. The dustbin automatically sends messages, so as to collects garbage efficiently. The message is sent by writing a code in Arduino.

The ultrasonic sensor is connected to the Arduino through the digital pins. If waste in the dustbin exceeds beyond a threshold value, Arduino will send the control signals to all its subsystems used in the design. After sensing the distance from ultrasonic sensor Arduino will send its control signal through digital output pins. We have used Arduino so that using the Arduino IDE platform and it is programmed based on the algorithm shown in Fig. 2. Waste can increase suddenly in a dustbin depending on

occasion and place. So, it is inefficient for the truck to go to a place and unnecessarily waste fuel for clearing waste of one dustbin while remaining bins of that location are still not full.

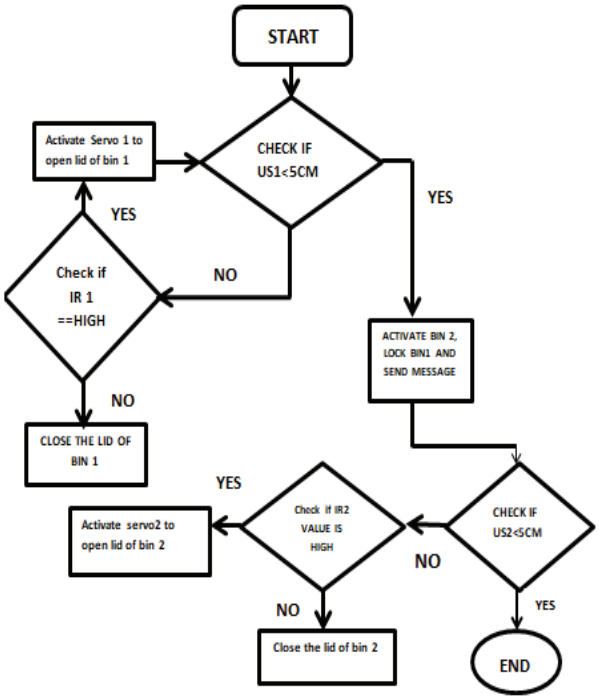

Fig.2: Algorithm of our Dustbin model

The backup bin gives extra time so that waste can be picked more efficiently and a lot of fuel can be saved because all bins of a location can be cleared in single attempt. The Arduino is programmed in such a way that message can be sent when the bin is half full and when the bin is completely full.When the distance of waste measured from the top is less than 5cm, it is decided that Bin A is full and Bin B is activated such that person who picks waste can take time to pick the waste but he must ensure that bin A is cleared before Bin B is full so that there is no inconvenience caused to users of the dustbin. The automatic open and close feature makes the dustbin more efficient. Now, Bin A will not open until authority clears the waste. There is an ultrasonic sensor in Bin B also which reads the level of the waste-filled inside the bin.

The model is working very well. If waste overflow from dustbins is solved, it decreases foul smell in surroundings of bin and users will use the bins with comfort. Our model enables waste collection staff to monitor bins from a control room in real time and get alerts from the dustbin, so that they can pick up waste effectively and treat the waste in time. Also, the person who gets alert from the bin will be responsible for cleaning it in time and will be left with no excuse.

III. Results And Discussion

All the hardware modules are implemented in real life dustbins as shown in Fig. 3 and 4. Figure 3 demonstrates the working of IR sensors to detect the presence of a person, which gives the signal to Arduino and finally Arduino instructs the servo motor to open the lid of the dustbin. Therefore, the automatic closing and opening of lid help the person to throw the garbage inside the dustbin without touching it. This will help to reduce the spreading of diseases.

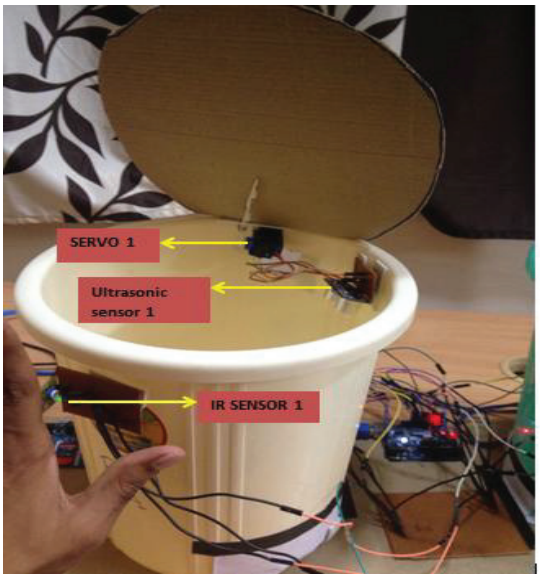

Fig.3: Ultrasonic sensor and servo motor place in the bin

Further, the proposed model includes double dustbins to address the issue related to delay in pick-up or damage the bins. Figure 4 shows the implementation of double dustbin concept, where Dustbin A initially works and Dustbin B will not open until and unless Dustbin A filled fully. Moreover, from Fig. 4 clearly demonstrates that the Dustbin B is closed even if there is an obstacle in front of Bin B. Whereas Dustbin A is open because of an obstacle in front of it.

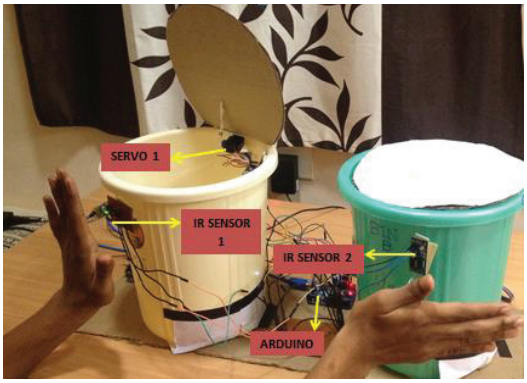

Fig.4: Status of the bins when Dustbin A is not full.

When we increased the level of waste in the Dustbin A, after reaching a level the following message is sent to the control room as shown in Fig. 5. GSM Module plays a key role in sending the message. As the ultrasonic sensor measured a distance less than 5 cm indicating filled up fully, the servo closes the lid of bin A and a message is conveyed.

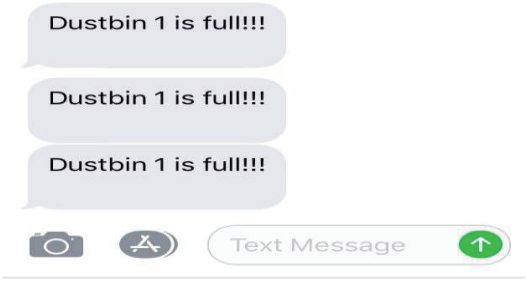

Fig.5**:** Text message received by the authorized mobile

Now, the Dustbin A will completely close and will not open until the bin is cleared. The backup bin comes into action and will monitor the waste thrown in it. The working of Bin B is shown in Fig 6. Even though there is an obstacle in front of Bin A, the servo pin does not go high and lid will not open. But, due to the presence of obstacle in front of Bin B, the servo pin of Bin B goes high and lid of the Dustbin opens. This Bin B will give extra time for authority to pick up the waste. Therefore, it is evident from the above results that the present concept of automated double dustbins is verified and also follows the proposed algorithm.

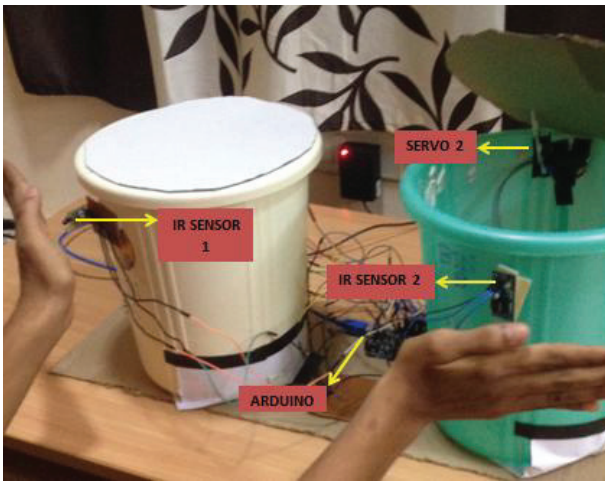

Fig.6**:** Text message received by the authorized mobile

Further, the present model also demonstrates that along with intimation to collection center it also provides an additional facilities to collect the dustbins. If the only message is sent the authority should immediately come and collect the waste. But it is not a good idea to start a trip to clear waste in a single bin as other bins can still be utilized and are not full. Fuel efficiency will be a concern. In our model, the bin B will provide authority more time to pick the waste.

IV. CONCLUSION AND FUTURE SCOPE

Waste management and disposal is one of the major challenges in all the cities. The present papers presents a dual dustbins system for automated operation of dustbins with advanced dynamic routing and higher optimized routes for trucks to collect the wastes, saving both time and money. The proposed waste management model is implemented in small scale using the Arduino, IR, ultrasonic sensors, GSM module, servomotor and 12V battery supply. The current systems takes care of delay in garbage pick-up, automatic accessing of dustbins along with intimation to collection center through SMS. Although the present model use double bins instead of one, it will be more useful, can contribute a lot towards the clean and hygienic environment in building a smart city. Further the present model will be made more user friendly and cost effective by connecting an LCD display to indicate the status of the bins and generating the required energy at the sensor node itself to make them self-sustainable. Finally the data from all these smart dustbins will be made available on a webpage so that the bins are monitored in control room.

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